Section of Anæsthetics.

President—Mr. GEORGE ROWELL, F.R.C.S.

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Anæsthetics at a Casualty Clearing Station.

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SURGICAL operations performed at a Clearing Station are for the most part urgent. It is often imperative to operate on men within a few hours of their injury while they are still suffering from the effects of shock and hæmorrhage. The patients have had to travel some miles from the line by motor ambulance over indifferent roads, and many have been exposed to cold and wet. A correct choice of anæsthetic is of the first importance: the patient's life will be as much imperilled by faulty judgment on the part of the anæsthetist as by a wrong decision on the part of the surgeon. There are other cases in which the condition is rendered grave by sepsis, especially gas gangrene; but there remains the majority whose wounds are slight and whose general condition is good.

ANÆSTHETICS USED.

The methods of anæsthesia I have employed are: Ether and chloroform by the open method; ether and chloroform by Shipway's warm vapour apparatus; intravenous ether; spinal anæsthesia with stovaine; nitrous oxide and oxygen; local infiltration with novocain, &c.

Let us consider the choice of anæsthetic in the various types of cases. We will deal first with the lightly wounded, as they are both the most numerous and the least interesting. Our patients have not been prepared for an anæsthetic, so that when brought into the theatre the bowel is full and often the stomach as well. In winter months,

difficulty is further increased by the prevalence of bronchitis. A large proportion of the men have cough with expectoration. Autopsies on men who have died of wounds, even when they have had no anæsthetic, commonly show the lung tissue to be congested while there is excess of secretion in the tubes. In spite of these failings, the lightly wounded are good subjects for anæsthesia. They are for the most part young and healthy; they are placid, and have little fear of operation.

The work of a Clearing Station comes in rushes, so that for slight cases the main considerations are safety, speed, and convenience. The ideal anæsthetic is one with which induction is rapid, and recovery complete a few minutes after operation, so that the patient is in fit condition for early evacuation by ambulance train. Apparatus is subjected to much wear and tear, so it should not be complicated or delicate.

Of the anæsthetics I have used, gas and oxygen meets these requirements best. Its only drawbacks are that the apparatus is somewhat cumbersome and the materials costly. Local anæsthesia can only be employed in a small number of cases on account of the multiplicity of wounds and their lacerated and soiled condition. Ether remains the most generally used anæsthetic. The great majority of slight cases are anæsthetized by Shipway's warm vapour method. For induction the mixed vapours of ether and chloroform are used; the process is free from struggling, so that it is seldom necessary for an assistant to stand by the patient. It is rapid: in a hundred cases which were timed induction was invariably complete in five minutes. Anæsthesia is maintained with ether alone. There is an absence of secretion, and atropine is not given unless the patient has signs of bronchitis. Consciousness is regained quickly, and vomiting has occurred in only 26 per cent. of all cases, including abdominal cases. Since the warm vapour method was introduced in this Clearing Station last winter, the drop-bottle has passed out of use. Compared with the open method there is a saving of at least 60 per cent. of ether. There is much less diffusion of the anæsthetic into the atmosphere of the theatre. This is an important consideration to those working in it at times of sustained pressure.

Spinal Anæsthesia.

In choosing an anæsthetic for the more seriously wounded, the one overwhelming factor is safety. We require a method which will not be harmful to a patient suffering from the shock of injury, and one

which will minimize the shock of operation. It has been urged that spinal anæsthesia would meet these requirements and would therefore be of great value in military surgery. For men wounded in the lower extremities I found it a convenient and satisfactory method at a base hospital; cases of profound collapse did not occur. The same good results were obtained at a Clearing Station in all patients who had been wounded not less than forty hours before operation. Of the more recently wounded, however, more than half showed signs of cerebral anæmia with great fall of blood-pressure shortly after intrathecal injection of stovaine. These signs were pallor, nausea, retching, vomiting, and loss of consciousness. More rarely I have seen extreme restlessness, and in one case convulsions. The radial pulse disappears and the patient presents an alarming picture of collapse which may necessitate interruption of the operation. It has been stated that collapse during spinal anæsthesia is not dangerous. I have seen two cases in which it proved fatal, and have heard of a number of similar fatalities in recently wounded men.

It is to the man whose wounds are less than forty hours old, and who has lost blood, that spinal anæsthesia is dangerous. This is shown by an analysis of fifty consecutive cases of wounds of the lower extremities operated on at a Clearing Station under stovaine spinal anæsthesia. The drug was used in 5 per cent. solution, in most cases with glucose. A dose of 1 to 2 c.c. was given; when smaller doses were used anæsthesia was incomplete, or came on so slowly as to make the method impracticable at a Clearing Station. During injection the patient was placed in either the Barker or sitting position, head and shoulders were kept high for the first fifteen minutes, and then horizontal.

Of the recently wounded patients, by no means all collapse under spinal anæsthesia. It is important that one should be able to recognize beforehand which cases will tolerate this procedure. Is there any physical sign which will prove a reliable guide? The appearance of the patient is of little assistance, the pulse-rate and blood-pressure do not help us at all. A valuable indication is obtained by determining the concentration of the blood. The method I employ is to estimate the percentage of hæmoglobin in the patient's blood by means of a a Haldane hæmoglobinometer. This method is simple, sufficiently accurate, and only takes a few minutes to complete. A low percentage of hæmoglobin—i.e., dilute blood—in a man recently wounded, may be taken to mean that he has lost blood. Control observations on healthy

unwounded soldiers showed the normal range of hæmoglobin to be from 97 to 120 per cent. with an average of about 110 per cent. as against my standard indicator. In practice I find that if a recently wounded man has a hæmoglobin percentage of over 100, it is safe to administer stovaine intrathecally. If the reading is below 100 per cent. he will almost certainly show a serious fall of blood-pressure and symptoms of collapse. In these fifty cases the hæmoglobin percentage, blood-pressure, and pulse-rate were recorded before the injection of stovaine. After injection, blood-pressure and pulse-rate were registered at intervals of about two and a half minutes for not less than fifty minutes. The blood-pressure was estimated by means of a Riva-Rocci sphygmomanometer with stethoscope over the brachial artery.

We will divide the fifty cases into three classes:—

Class A.—Men operated on within forty hours of receiving their wounds, whose blood was dilute—i.e., hæmoglobin under 100 per cent.

Class B.—Men operated on within forty hours of receiving their wounds, whose blood was *not* dilute—i.e., hæmoglobin 100 per cent. or over.

Class C.—All cases in which a greater interval than forty hours had elapsed between wounding and operation, whether the blood was dilute or not.

In Class A—i.e., short interval cases with dilute blood—we have twenty-two examples. Of these twenty-two all but three showed symptoms of collapse after injection of stovaine. The average fall of blood-pressure was 57 mm. of mercury. In only three cases was the fall of pressure less than 35 mm., the greatest fall was 99 mm.

In Class B—i.e., short interval cases in which the blood was not dilute—there are sixteen examples. Of these sixteen thirteen showed no untoward symptoms whatever after injection. Of the remaining three one complained of nausea, and in the other two pallor was the only sign. The average fall of blood-pressure was 17 mm. of mercury, and the greatest fall was 33 mm.

In Class C—i.e., men wounded more than forty hours—there are six examples. None showed any symptoms of collapse. The average fall of blood-pressure was 19·7 mm., and the greatest was 35 mm.

If we divide the cases into classes according to the length of time which elapsed between reception of wound and operation, we find that, until we deal with intervals exceeding forty hours, cases with dilute blood suffer a big fall of blood-pressure, while the fall of pressure in cases with blood of normal concentration is less than half as great.

When the interval exceeds forty hours the fall of pressure in both types is small and about the same.

Interval	Average fall of blood-pressure in cases with: Dilute blood	Blood not dilute
1 to 10 hours	72 mm. ...	19 mm.
11 to 20 ,, ...	45 ,, ...	14·6 ,,
21 to 30 ,, ...	57·5 ,, ...	17·7 ,,
31 to 40 ,, ...	71 ,, ...	25 ,,
41 to 50 ,, ...	28 ,, ...	31·5 ,,
51 hours to 23 days	10 ,, ...	7 ,,

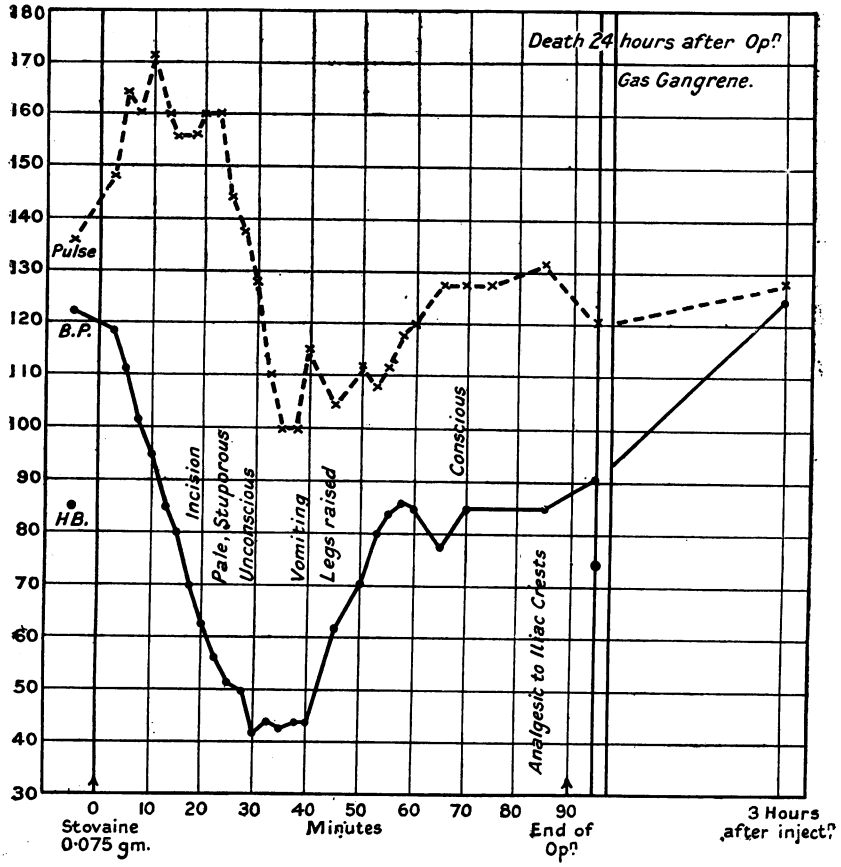

CHART I.

Spinal anæsthesia level 3 in. above umbo and buttock. Class A. Shell wound, leg, twenty-one hours; wounds excised and drained. Hæmoglobin, 85 per cent.; blood-pressure fell 81 mm.

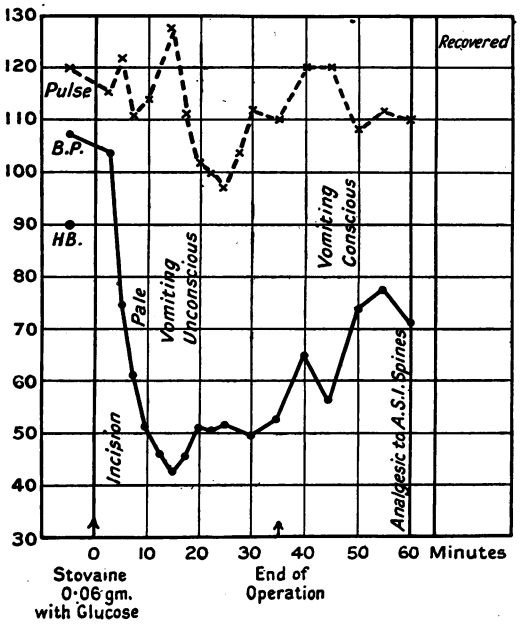

CHART II.

Spinal anæsthesia level umbilicus. Class A. Bomb wounds, neck and legs, seven hours. Left fibula fractured; patient's colour healthy; operation wounds excised. Hæmoglobin, 90 per cent.; blood-pressure fell 66 mm.

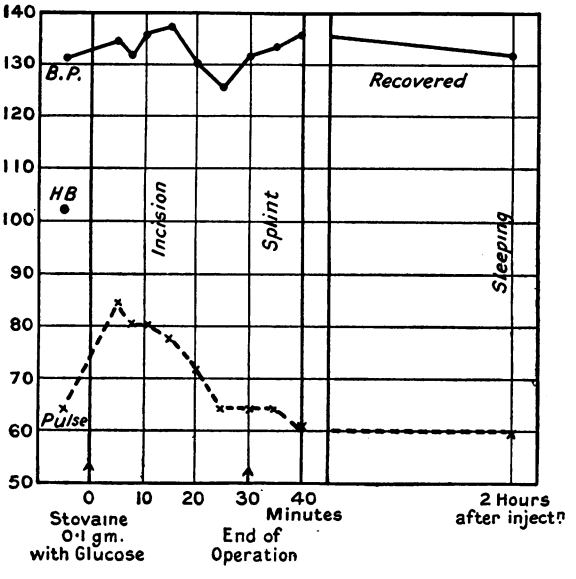

CHART III.

Spinal anæsthesia level iliac crests. Class B. Shell wound, thigh, sixteen hours; patient's colour healthy; wounds excised and projectile removed; symptoms *nil*. Hæmoglobin, 102 per cent.; blood-pressure fell 6 mm.

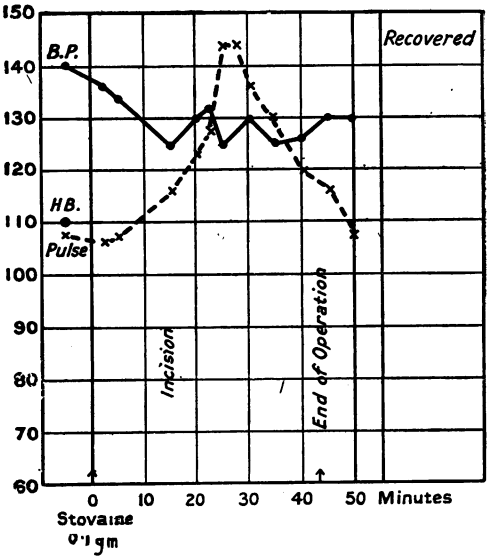

CHART IV.

Spinal anæsthesia level costal margin. Class B. Bomb wounds, buttock and thigh, twenty-one hours; patient's colour healthy; wounds enlarged and metal removed: symptoms *nil*. Hæmoglobin, 110 per cent.; blood-pressure fell 15 mm.

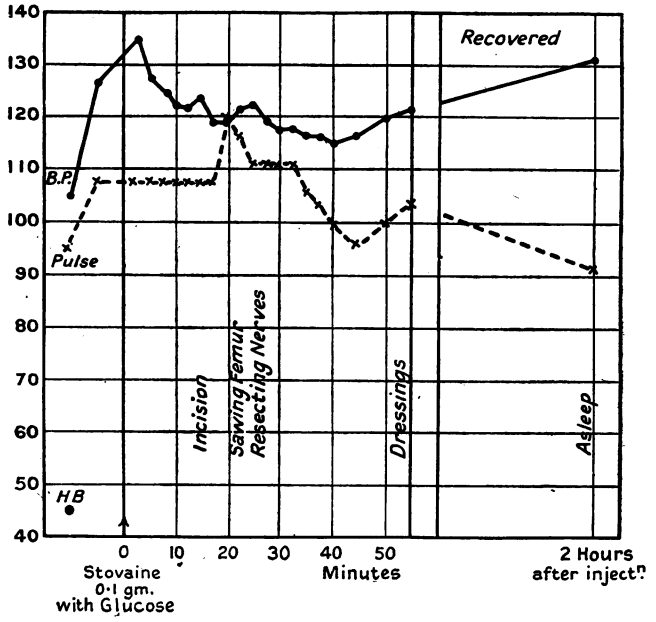

CHART V.

Spinal anæsthesia level 1 in. below umbilicus. Class C. Shell wounds, thigh and femoral artery, twenty-three *days*; temperature 102° F.; foot gangrenous; amputation lower third of thigh with flaps. Hæmoglobin, 45 per cent.; blood-pressure fell *nil*.

I said that neither the blood-pressure nor the pulse-rate indicate whether a recently wounded man is a suitable subject for intrathecal stovaine. We have seen that these cases may be divided into two classes according to whether the blood is dilute or not, and that these two classes react very differently to spinal anæsthesia. There is, however, little difference in the average initial pulse-rate and blood-pressure of the two types. Thus—

	Class A	Class B
Average initial blood-pressure ...	130 mm. ...	129 mm.
Range of ,, ,, ,, ...	90 to 182 mm. ...	115 to 150 mm.
Average initial pulse-rate	105 ...	88
Range of ,, ,, ,, ...	70 to 140 ...	64 to 140

As regards the appearance of the patient, some of those in Class A were obviously pale but many were not, although estimation of the hæmoglobin showed their blood to be dilute. These patients suffered collapse as profound as those in whom loss of blood was obvious clinically. The deduction I would draw from these observations is that stovaine should not be administered intrathecally to men who have been wounded less than forty hours, unless it has been demonstrated that their blood is of normal concentration.

Whether other drugs, such as novocain, would be equally dangerous I have had no opportunity of determining. We have found the heavy type of solution more satisfactory than that without glucose. The level of anæsthesia is more easily controlled when using the heavy solution. As regards fall of blood-pressure, results were about the same with the two solutions. The dose of stovaine varied from 0·05 to 0·1 grm., and within these limits fall of blood-pressure was not proportional to dose of drug. Some of the greatest falls of pressure were associated with the smallest doses of stovaine, and vice versa. Nor was the fall of blood-pressure proportional to the level of anæsthesia.

I will leave it to others to explain why men who have recently lost blood should collapse under spinal anæsthesia. Perhaps loss of blood is not the only factor. In secondary hæmorrhage there is loss of blood without shock of injury. Do these cases collapse after the injection of stovaine? I have no experience.

As regards prevention or combat of the collapse, the most important factor is position of the patient. Fifteen minutes after injection the head should be lowered, and it should be kept low for at least an hour. The practice of propping the patient up on his return to bed is dangerous. One patient in this series, who had no alarming symptoms

when in the operating theatre, was propped up on his return to the ward. He became blanched, pulseless, and unconscious. He recovered when the head was lowered, the legs raised, and pressure put on the abdomen. Another patient, whose head and shoulders were raised on his return to the ward, died straightway.

Subcutaneous injection of strychnine appears to be without value, both as a preliminary measure to prevent collapse, and subsequently in its treatment. Intramuscular injection of pituitrin proved useless in combating the fall of blood-pressure. Intravenous saline caused temporary improvement in the one case in which it was tried, but the blood-pressure fell again after one and a half hours, and the patient died. This last case was a man with a penetrating wound of the abdomen. Our experience of spinal anæsthesia for these cases has been limited and unfortunate. Three men with penetrating wounds of the abdomen were each given 0·07 grm. of stovaine. In each case the injection was followed by a great fall of blood-pressure, and death within a few hours. Lest you should attach undue importance to the personal equation, I should like to say that with spinal anæsthesia for appendicectomies our experience has been free from all alarms.

Wounds of the Limbs of Extreme Severity.

The type of case I refer to is the man suffering from shock. The wounds are recent, and one or more of his limbs are shattered. His face is pale, and the pulse flickering or imperceptible. Another characteristic of the badly wounded man is his low surface-temperature. If put to bed and surrounded with hot bottles his condition usually improves. The blood-pressure is taken every hour, and, if it is rising, operation is delayed. This delay must not be too long, or gas gangrene will supervene. The surgeon may be compelled to amputate a limb, and the anæsthetist is faced with a pulseless patient who has to undergo a brief but severe operation. The lives of many of these patients may be saved if correct procedure be followed. In the first place morphia should be withheld before operation, or given only in small doses. A recently injured man is particularly susceptible to further shock, and this susceptibility is greatly increased by large doses of morphia. It is my experience that a badly injured patient has a poor chance of rallying if he has received more than $\frac{1}{4}$ gr. of morphia before operation. If chloroform be used, the patient is likely to die on the table. With ether the patient's condition actually improves during operation, but

he will collapse an hour or two afterwards. If the ether be given intravenously, the patient's condition improves strikingly during administration, but there is profound collapse, which is often fatal, within the next two hours. The cause of death is not œdema of the lungs; in no case have I seen any evidence of this condition either clinically or at autopsy. In several cases there was œdema of the liver, and in one patient who died an hour and a half after intravenous ether the gut was œdematous from stomach to rectum.

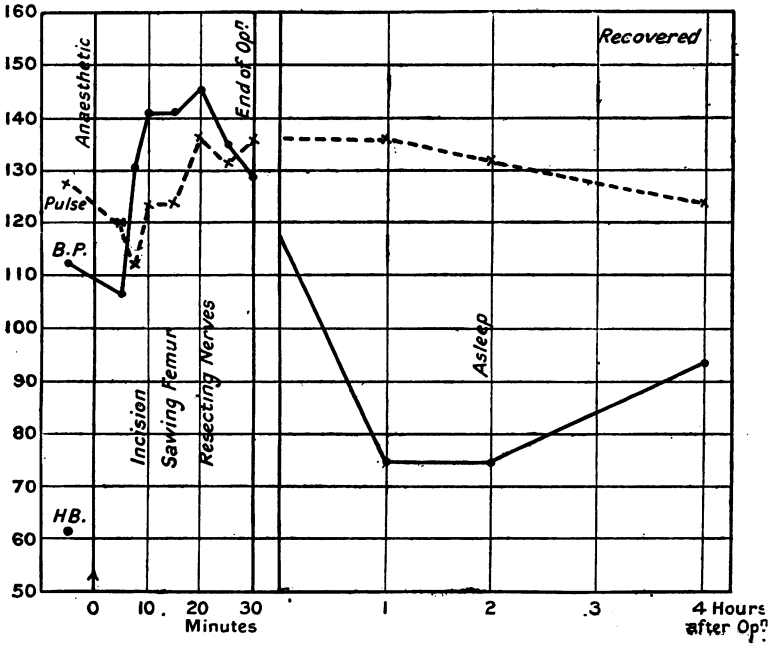

CHART VI.

Warm ether vapour and oxygen. Shell wound, leg, thirty-six hours; tibia shattered; amputation lower third of thigh; collapse during first two hours after operation.

Spinal anæsthesia is contraindicated, as I have already shown. Incomparably good results are obtained with gas and oxygen, and no other anæsthetic should be used for this type of case. Anæsthesia may be so light that the patient will move when nerves are resected. There is practically no evidence of shock from the operation, even when this is an amputation through the upper part of the thigh. In few of these cases has the blood-pressure fallen 15 mm., or the pulse-rate risen

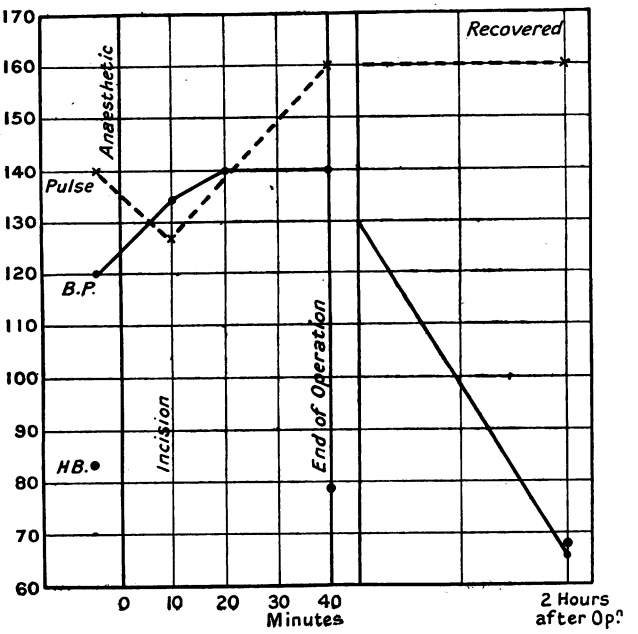

CHART VII.

Intravenous ether, 6 per cent., 45 oz. Shell wound, thigh, femur fractured, twenty-two hours; excision of wounds and drainage; bad collapse two hours after operation.

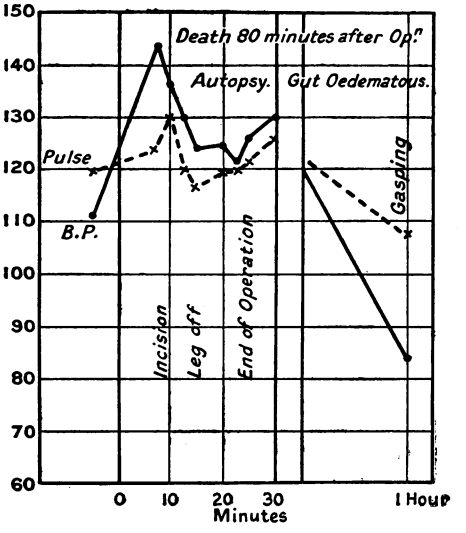

CHART VIII.

Intravenous ether, 6 per cent., 60 oz. Shell wound, leg, six days. Secondary hæmorrhage twelve hours before second operation. Hæmoglobin, 43 per cent. Circular amputation mid-thigh; collapse and death.

more than ten beats per minute. The patient is fully conscious five minutes after operation, and can literally "sit up and take nourishment." There is no collapse during the next few hours, and the subsequent progress is notably good. (*See* Charts VI, VII, VIII, and IX.)

There is another class of patient who is gravely ill but who is *not* suffering from shock—I mean the septic case. Early sepsis commonly takes the form of gas gangrene. In a typical case the patient vomits repeatedly, his face is of a pale muddy colour, his pulse feeble and running. In spite of this apparently desperate condition, such a patient is a much more favourable subject for anæsthesia than one who is suffering from shock.

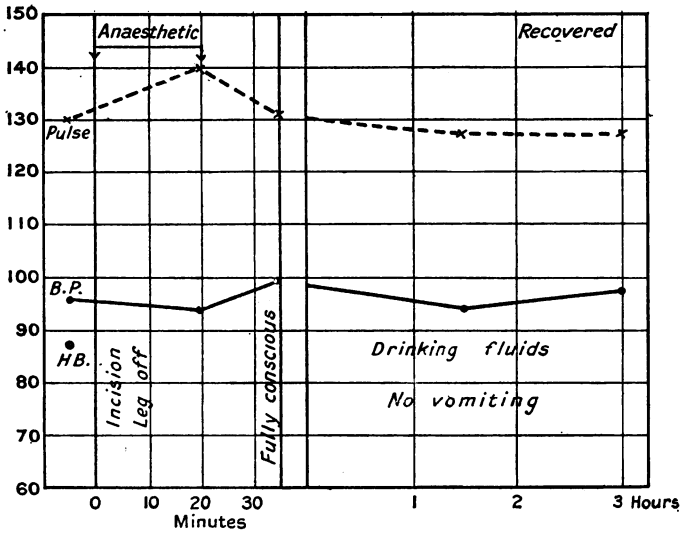

CHART IX.

Nitrous oxide and oxygen. Shell wound, thigh, twenty-one hours; lower end of femur smashed; patient pale and vomiting; circular amputation mid-thigh; no collapse, and practically no effect on blood-pressure or pulse-rate.

Intrathecal stovaine, which causes collapse in the recently wounded man, has no such effect on this same man some days later, although sepsis may have rendered his general condition much more serious. This same distinction is seen with ether anæsthesia, whether the ether be given intravenously or by inhalation. The collapse which occurs after operation on a man who is suffering from shock or recent hæmorrhage, is not seen in these later and septic cases. Some of the most

brilliant results have been obtained with intravenous ether; the improvement in the patient's condition, which occurs during administration, is maintained afterwards, and vomiting seldom recurs.

Gas and oxygen also gives excellent results. Chloroform is to be avoided: if this drug be used the man's blood-pressure will fall after operation, and he is likely to die within the next twelve hours. (*See* Charts X and XI.)

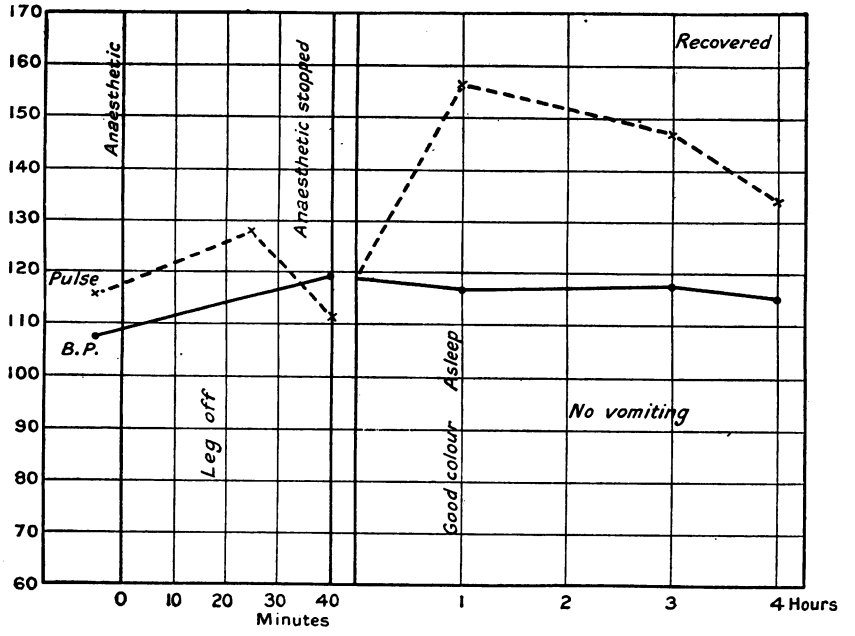

CHART X.

Intravenous ether, 7 per cent., 44 oz. Shell wound, both thighs, fifteen days; left thigh amputated, thirteen days; infection of right knee-joint and thigh muscles; temperature, 101° F.; persistent hiccup and vomiting; amputation lower one-third of right thigh with flaps; no collapse.

WOUNDS OF THE HEAD.

There is now general agreement that chloroform is a bad anæsthetic for head cases. Operation may be performed under local anæsthesia; all tissues of the scalp are infiltrated in a circle widely surrounding the site of incision. We generally use a 0·2 per cent. solution of novocain with adrenalin. No pain is felt even when bone or dura are dealt with. On the other hand, the forcible cutting of bone is disturbing to the patient, so that where mentality is unimpaired general

anæsthesia is preferable. Warm ether vapour is exceedingly satisfactory. The vapour is given by means of a catheter passed down the more patent of the two nostrils; thus the mask is dispensed with and the surgeon has a clear field. The ether is vaporized by passing oxygen through it. Breathing is easy and noiseless and there is no congestion, whatever the position of the patient's head, so that hæmorrhage is not unduly provoked.

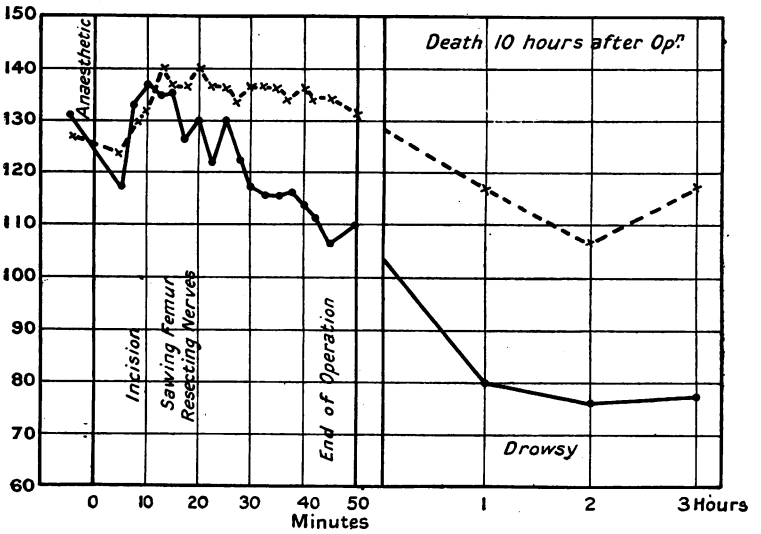

CHART XI.

Warm chloroform and oxygen. Shell wound, seven days, knee-joint infected. Late case, septic, but in fair condition; blood-pressure fell after operation (re-amputation lower one-third thigh) and patient died ten hours later.

WOUNDS OF THE ABDOMEN.

It is in this group of cases that the warm vapour method has shown to the full its striking advantages. The quiet induction, free from struggling, may save much loss of blood from wounded vessels in the peritoneal cavity. The easy breathing and diminished heat-loss leave the patient in remarkably good condition at the end of a long operation. With regard to heat-loss it is interesting to note that with warm ether vapour I have never seen the so-called ether tremor or shivering fit, which is commonly associated with open ether. The absence of vomiting makes it possible to give fluids by the mouth within two hours of the patient's return to the ward. Men with abdominal wounds are particularly liable to develop bronchitis, perhaps owing to the deficient

movement of the lower part of the chest. With open ether 54 per cent. of our abdominal cases had bronchitis after operation. With warm ether vapour the percentage has dropped to 14·7. These figures were obtained from two comparable series occurring in the same months of two successive years; only those cases were counted which survived operation more than forty-eight hours.

During the progress of an ether vapour anæsthetic, the blood-pressure shows a tendency to rise. If the operation involves much manipulation of gut and pulling on peritoneum, the pressure will fall. This fall, however, will be slow, and the process may be continued for hours without reducing the blood-pressure to a dangerous level.

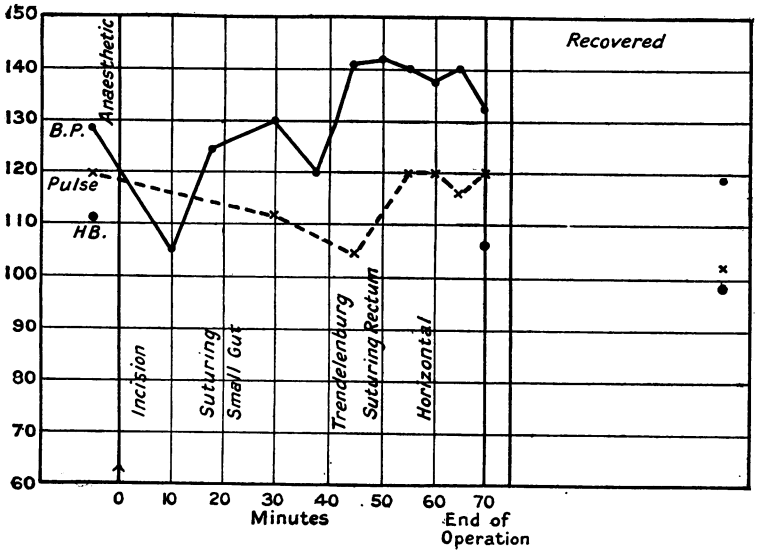

CHART XII.

Warm ether vapour and oxygen. Gunshot wound, abdomen, ten hours; patient pale; gut kept inside abdominal cavity during operation; operation suture of several holes in ileum and one in rectum; no fall of blood-pressure.

Exposure of gut outside the abdominal cavity produces a much more serious effect on the patient. If more than 2 or 3 ft. of gut are so exposed, after a few minutes the blood-pressure commences to fall rapidly and it continues falling until the gut is returned to the abdomen. This effect is seen when the stomach and omentum are exposed, and even with the great omentum alone. The covering of exposed viscera with pads soaked with hot saline does not prevent this effect on the

patient's condition. Nevertheless it seems probable that the cause is heat-loss from exposed blood-vessels. Exposure of gut produces much less effect on a man who is not under an anæsthetic. I have seen men arrive from the line with several feet of intestine prolapsed through a wound, yet their blood-pressure was within normal limits. In one case more than two-thirds of the small gut had been outside the abdominal cavity for at least four hours, yet this man's blood-pressure was 142 mm. of mercury and his pulse-rate only 108: the patient recovered. Surgeons should be urged to make large incisions and work as much as possible with the gut lying inside the peritoneal cavity.

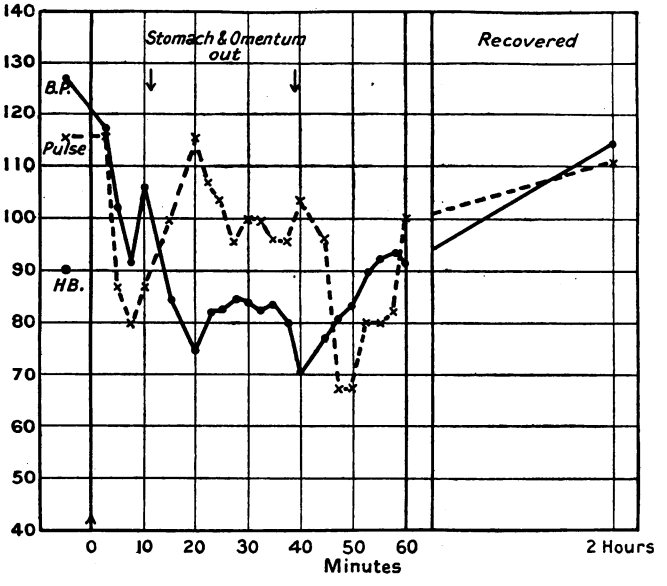

CHART XIII.

Warm ether vapour and oxygen; subcutaneous saline 1½ pints. Gunshot wound, abdomen, six hours; tear in liver packed; two holes in stomach sutured; stomach and omentum outside abdomen during operation; blood-pressure fell 48 mm.

Apart from copious hæmorrhage there is one other procedure which causes rapid fall of blood-pressure during abdominal operations. This is turning the patient on his side. The effect is produced only if the patient has been under the anæsthetic for a considerable time before being turned. At the end of an abdominal operation the patient may be in good condition; he is then turned on the right or left side, in

order that the surgeon may excise a wound in the back. In a few minutes there is a great fall of blood-pressure and the radial pulse disappears. It may be hours before the patient recovers this lost ground. The indication is that wounds of the back should be dealt with before laparotomy, as turning the patient has no ill effect during the first half hour of an ether anæsthesia. (*See* Charts XII, XIII, XIV, XV, and XVI.)

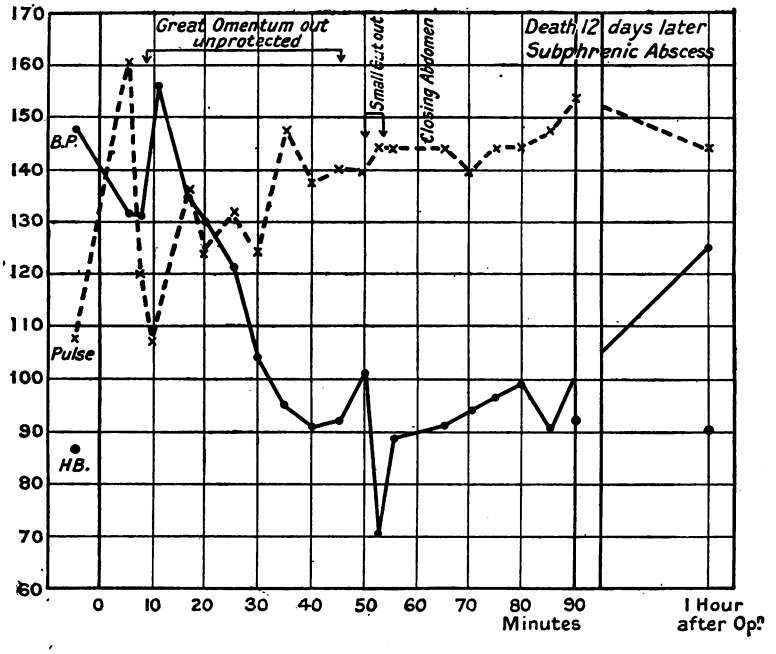

CHART XIV.

Warm ether vapour and oxygen. Gunshot wound, abdomen, arm, and chest, nine hours; hole in stomach sutured; great omentum only exposed outside abdomen; blood-pressure fell 55 mm.; further fall towards end when small gut was brought out; death at end of twelve days.

For abdominal cases I give oxygen with the ether vapour; no atropine is administered before operation as I have not been able to discover any advantage from giving it. Ether gives better results than chloroform in these cases. With chloroform the blood-pressure falls steadily, and if operation be prolonged the patient may die before the abdomen is closed, or shortly after. There is one type of abdominal case for which chloroform has advantages—this is the man who has a

penetrating wound of the chest as well as of the abdomen. Here ether cannot be used, as it will, in the majority of cases, provoke fatal intrathoracic hæmorrhage. To these patients I now give hyoscine $\frac{1}{100}$ gr., atropine $\frac{1}{100}$ gr., and morphia $\frac{1}{6}$ gr., forty minutes before operation. This is followed by a minimal amount of warm chloroform vapour with oxygen. With this sequence our recovery rate has greatly improved in the chest-abdomen cases, while in the men who died there was no evidence of fresh bleeding into the chest.

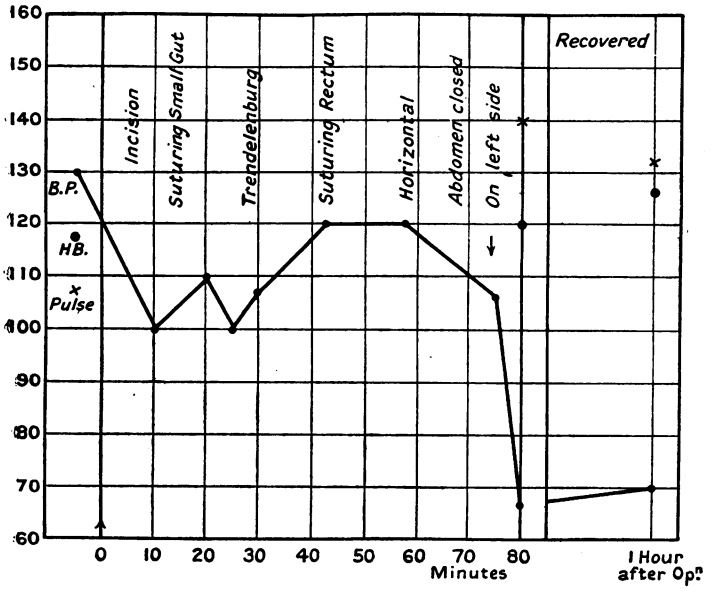

CHART XV.

Warm ether vapour. Shell wound, abdomen, two and a half hours; holes in small gut and rectum sutured; patient turned on side sixty-five minutes after commencement of anæsthetic; blood-pressure fell 30 mm.; patient remained pulseless for two hours.

With regard to fluids, it has been our practice to give three pints of normal saline subcutaneously during operation. For the collapsed cases this seems to be useless; they do not absorb the fluid. Autopsies on men who have died as late as thirty hours after operation have shown the bulk of the fluid to be still in the subcutaneous tissues near the site of injection. To these collapsed patients we give saline intravenously, towards the end of operation. Only a very temporary effect is produced on the blood-pressure if transfusion is completed in the early

stages of operation. I find that hypertonic saline raises the blood-pressure, slows the pulse-rate and dilutes the blood for a longer period than does the normal solution. I hope to give definite records illustrating this point at some later date.

In concluding I wish to acknowledge my debt to my commanding officer and to the medical officers of the Clearing Station to which I am attached. They have given me every assistance in making observa-

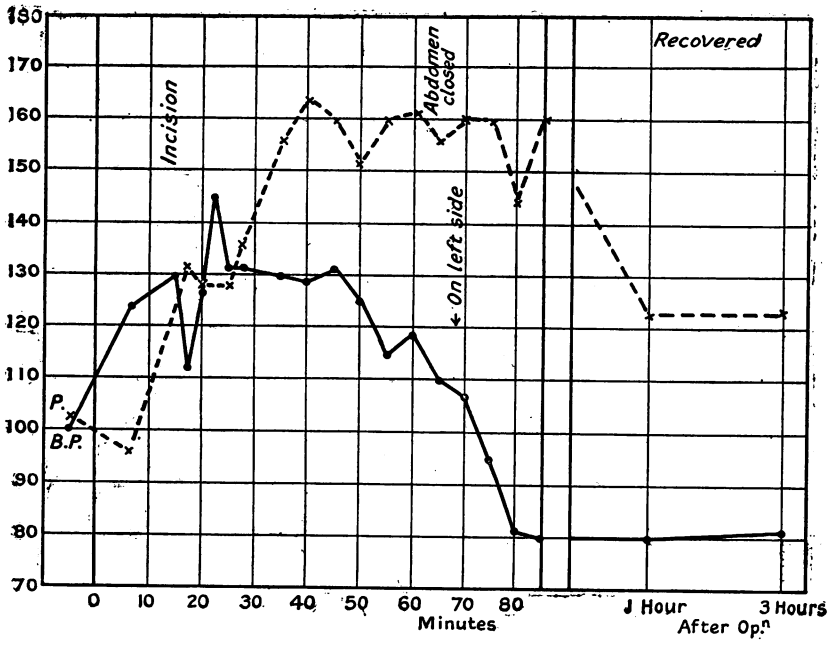

CHART XVI.

Warm ether vapour and oxygen. Shell wound, abdomen and leg; operation, suture of holes in small gut and colon; patient turned on side after seventy minutes of anæsthetic; blood-pressure fell 43 mm., and patient was pulseless for an hour.

tions on cases under their care. They have authorized me to say that they are in substantial agreement with the views expressed in this paper. I must add that our views on the choice of anæsthetic for the more difficult cases met with at a Clearing Station are subject to frequent revision. I welcome this opportunity of provoking criticism from those whose experience is so much greater than mine.

DESCRIPTION OF CHARTS.

Explanation.

The continuous line with black dots represents systolic blood-pressure in millimetres of mercury.

The dotted line with crosses represents pulse-rate per minute.

The black dots represent hæmoglobin percentage (normal would be about 108 per cent. with my standard).

Scale for above three curves is marked up the left-hand vertical line.

The next vertical line marks beginning of anæsthetic.

The double vertical line on the right marks the point where the patient leaves the operating table.

Scale of time is marked along base-line. During operation it is marked in minutes, after operation in hours.

DISCUSSION.

Mr. BELLAMY GARDNER: Captain Marshall has shown us the effects and requirements of severe shock and hæmorrhage such as we can experience only to a slight degree in civilian practice. We must realize that the weak anæsthetics and gentle treatment needed in the presence of profound shock must not be advocated for wounded soldiers as we see them in home hospitals, where their health and muscular development render them amongst the most resistant types for anæsthesia.

Mr. H. E. G. BOYLE: I believe that gas and oxygen, with a little ether when necessary, given by a Gwathmey apparatus, provide us with a better anæsthesia and more favourable after-state than can be obtained by any other method. I wish to know Captain Marshall's opinion with regard to patients who have been gassed and who subsequently take anæsthetics. In one such case a man who had been gassed some weeks before was given gas and ether and chloroform. Nothing abnormal occurred, but subsequently I was informed that he died on the third day and that his room smelt strongly of chlorine.

Colonel HUGH RIGBY: My contribution to this discussion is merely the impressions of a surgeon and onlooker. Seeing many busy clearing stations I had good opportunities of judging the popularity and value of different forms of anæsthesia employed. Intraspinal, intravenous, and inhalation anæsthesia, all came before my eyes. The first was good in patients in fair condition with lower limb injuries; it was most convenient and economical in times of stress. Stovaine was always used and gave the best results combined with glucose. A case which showed the possible danger of ether infusion impressed me strongly, for the death which followed three hours after operation was

attributed to the cooling of the solution employed. I saw alcohol infused on one occasion only, and little was achieved beyond giving the patient, a German, a pleasurable sense of exaltation, much to the disgust of the anæsthetist. With regard to inhalation anæsthetics the choice was often difficult. The seriously wounded to be dealt with were of three classes: (1) Those suffering from shock due to injury and exposure; (2) those who had, in addition, suffered from severe hæmorrhage; (3) those who were the subjects of acute toxæmia from infection, usually with gas-forming organisms. A warmed ether vapour, with or without chloroform, was the popular anæsthetic, and those who used the method were of opinion that struggling, vomiting, and lung complications were diminished by its use. Gas and oxygen was absolutely invaluable in desperate cases.

Mr. H. TYRRELL GRAY: Captain Marshall associates the fall of blood-pressure during spinal anæsthesia with the degree of concentration of the blood. He has not made out a case strong enough to justify so definite a view. Blood-pressure readings at much shorter intervals are required. The stovaine glucose solution causes collapse more readily than Chaput's solution of stovaine in saline. There are many causes of collapse during spinal anæsthesia: firstly, *stovaine poisoning* from absorption of the drug through the cranial venous sinuses, which it reaches by diffusion in the cerebrospinal fluid; secondly, *cerebral anæmia*, which may be caused by mental disturbance, and by paralysis of the lower intercostal and abdominal muscles; thirdly, the suddenness with which paralysis spreads to the thorax and the consequent extent of the compensatory respiratory movements by accessory muscles. I believe the mental factor plays a most important part in the results observed by Captain Marshall and should like to see his observations repeated on cases in which spinal analgesia was combined with a liberal dose of morphia and some ether inhalation. I cannot agree with Captain Marshall's view as to the part that spinal analgesia may play in leading to gas gangrene. The period of low blood-pressure is too short to have such an effect, nor has it been shown that venous congestion predisposes to the onset of gas gangrene. Moreover, the lowest blood-pressures are by no means seen during spinal anæsthesia.

Captain MARSHALL (in reply): With regard to the administration of gas and oxygen, I use Hewitt's apparatus, which is the only one available. During induction I keep the valve at "four parts oxygen" and then gradually increase the proportion of oxygen, avoiding stertor and cyanosis. If there be a tendency to cyanosis when the valves are delivering the maximum proportion of oxygen, I cut out the gases altogether and give air. I have been fortunate in not having had any trouble with regard to vomiting into the respiratory passages. In only two cases have I seen alarming symptoms during administration; these cases were consecutive and were both men suffering from advanced sepsis. A distinguished anæsthetist has stated in one of the journals that gas and oxygen is dangerous in septic cases, and at first these two cases seemed to support that opinion. On investigation, however, I found that all

the oxygen inlets of my apparatus were stopped up by lubricating grease, and after clearing them I had no further trouble even in the septic cases. The President has stated that he has found that a preliminary injection of pituitrin minimized the fall of blood-pressure in spinal anæsthesia. I have not made use of the drug in this way but shall try it in future ; I have only given it after collapse has occurred and then no beneficial effect is obtained. Mr. Tyrrell Gray says that the blood-pressure charts are of little significance and that only drum-readings are of any value. I agree that drum-readings are the ideal, but believe that pressure readings taken at intervals of a few minutes give a very useful indication of the effect of anæsthetics and operative procedures on the patient's condition. It is the general experience of all skilled physiologists that in a smoothly conducted experiment the blood-pressure readings proceed on an even curve, and that abrupt and wide oscillations do not occur except as a direct and transient result of some accidental factor which is of no significance in the general curve, and ought to be eliminated. If blood-pressure readings in the human subject are continually showing the wide oscillations that have been described by Mr. Tyrrell Gray, it would be almost inconceivable that not a single one of these high oscillations should have been caught in the hundreds of observations the results of which are exemplified in these charts. The fall of blood-pressure in spinal anæsthesia is attributed by Mr. Tyrrell Gray to psychic disturbance. This seems improbable, as excitement causes a rise and not a fall of pressure. Moreover, why should the fall of pressure occur only in those whose blood is dilute? Is it suggested that a low percentage of hæmoglobin indicates that the patient will undergo a psychic disturbance in half an hour's time? If the psychic factor is abolished by general anæsthesia, the fall of pressure is not prevented. My experience is that with combined spinal and general anæsthesia the fall of pressure is more profound than when either form of anæsthetic is used separately. I consider that the fall of blood-pressure is due to the action of the stovaine in blocking the impulses which maintain the tone of the peripheral circulation : when an inactive sample of stovaine is injected into the theca practically no effect is produced on the blood-pressure. With regard to shock in wounds of the thigh, I have not found this severe except in cases where the bones or vessels were involved. It has been suggested that the fall of blood-pressure which occurs when a patient is turned on his side is due to dragging on the mesentery and consequent afferent stimulation. This explanation seems far-fetched, it is even doubtful if the mesentery would be dragged on appreciably. Is it not more probable that the cause is an interference with the mechanisms of respiration or circulation? The absence of shock in amputations of the thigh under gas and oxygen anæsthesia makes one wonder whether " afferent stimuli " are not being given more than their due in the theories of Dr. Crile and Mr. Tyrrell Gray.